

13 October 1998
B-B600-16538-ASI

Mr. R. Swaim, AS-40
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594-0003



Subject: Three-inch Bonding Rule, TWA 747-100 Accident off Long Island,
NY - 17 July 1996

Dear Mr. Swaim:

The following summarizes the work done on the subject of electrostatic charging by fuel of unbonded equipment inside fuel tanks and provides comments on the 3-inch bonding rule:

Electrostatic Testing

Boeing conducted electrostatic testing in late 1996. The FAA and NTSB provided comments on the test procedures and observed the testing. The issue at that time was whether a leak in the crossfeed manifold spraying on unbonded equipment could produce incendiary electrostatic discharge. Other issues were investigated as the testing evolved. Eight major groups of tests were accomplished, many of which were performed on a mock-up of the center wing tank fuel plumbing, using the same fuel pumps and tubes as those found on the 747-100. Components that were tested include Wiggins couplings with diameters ranging from 1.75" to 4.0", tube sections with diameters from 1.75" to 4.0" and lengths greater than 1 foot, 1.75" Teflon-sleeved clamps, 2.0" Nitrile-sleeved clamps, and 12"x12" aluminum plates. Voltage accumulation and streaming current was measured for fuel flowing *through* electrically-isolated tubes and couplings, as well as for fuel leaks and fuel sprays *onto* clamps, aluminum plates, sections of fuel tubing, and Wiggins couplings. Test variables included fuel temperature, pressure, conductivity, water content, and fuel pressure source. In addition, fuel "slosh" testing was conducted on electrically isolated clamps, couplings and tube sections that were placed in a partially-filled test tank. This tank then was oscillated to measure any voltage build-up. From test results, the stored electrostatic energy was calculated to compare with the maximum allowable energy in fuel tank electrical equipment design specified by Boeing (0.02 millijoules).

In all tests, no significant energy was able to be generated. If the test team observed a combination of faults that could generate voltage or current, they

fine-tuned the test further to find the peak voltage. No charging mechanism, even remotely close to what would be required to exceed the allowable energy level, could be found.

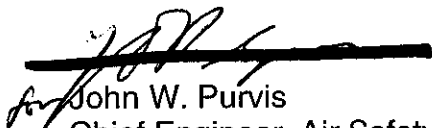



The 3 inch Bonding Rule

Applicable Boeing design requirements for the 747 Airplane Program do not specifically identify a documented rule to electrically bond equipment and components that exceed 3 inches in the largest dimension. Even though there was no formal program requirement to bond components larger than 3 inches, attention was given to conductive parts that might be electrically isolated from basic structure. Basic program engineering knowledge exists regarding the 3 inch rule as provided in MIL-B-5087, but only as reference material. Some credit is taken for incidental and inherent bonding where no deliberate attempt was made to isolate a component. For purposes of electrostatic charging, the 3 inch rule is a general guideline, communicated with designers when clarification was requested, that metallic components which do not exceed 3 inches in the largest linear dimension are not required to be bonded to structure, except where they act as a portion of the ground path. The electrostatic testing cited above validated this approach as good design practice.

Boeing considers the continuing study into the electrostatics phenomena a useful endeavor. As a matter of good design practice, it is evident that as the phenomena of electrostatic charging is configuration sensitive, each configuration for which any doubt exists should be tested. MIL-B-5087 has been revised to reflect this philosophy.

If you have any questions, please do not hesitate to call.

Very truly yours,


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cc: Mr. A. Dickinson, IIC